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Fate of Generic *Escherichia coli* in Beef Steaks during Sous Vide Cooking at Different Holding Time and Temperature Combinations

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Summary with Implications

Sous vide cookery utilizes water baths held at precise temperatures to cook food and has increased in popularity in domestic and food service settings due to ease of use and consistent final cooking temperature of food. Some *sous vide* manufacturers' cooking websites suggest cooking intact and non-intact beef products to internal temperatures as low as 115° F. To address the safety concerns of cooking non-intact beef products to temperatures below USDA-FSIS guidance temperatures, steaks were internally inoculated with a strain of generic *E. coli* and *sous vide* cooked to internal temperatures of 115, 125, 130, and 145° F and held for various times. A 5 log₁₀ reduction of generic *E. coli* was achieved after sufficient holding times for all temperatures except 115° F, which only achieved 1.07 log₁₀ reduction after 420 minutes of holding. These worst-case scenario results highlight the importance of using safe time and temperature combinations when *sous vide* cooking beef and warrant further investigation using pathogenic *E. coli*.

Introduction

Sous vide cooking has grown in popularity as cooking units have become more affordable and easier to use. This method of cooking by submerging a vacuum sealed product in a hot water bath held at a precise temperature allows for an exact degree of doneness throughout the product. However, some cooking guidelines distributed by *sous vide* manufacturers for cooking of beef create the potential for foodborne illness due to recommended cooking temperatures as low as 115° F. The United States De-

Table 1. Concentration of *E. coli* (log₁₀ cfu/g) during *sous vide* cooking.

Holding time (min)	log ₁₀ cfu/g	Total Reduction
115° F holding temperature		
Raw steak	7.41 ^a	n/a
150	7.37 ^a	0.04
420	6.33 ^b	1.07
125° F holding temperature		
Raw steak	7.02 ^a	n/a
150.0	3.88 ^b	3.14
193.5	2.21 ^c	4.81
258.0	1.22 ^d	5.80
322.5	0.39 ^e	6.63
130° F holding temperature		
Raw steak	7.13 ^a	n/a
64.5	0.51 ^b	6.62
86.0	0.47 ^b	6.66
107.5	0.73 ^b	6.12
145° F holding temperature		
Raw steak	7.25 ^a	n/a
2.25	0.42 ^b	6.83
3.00	0.42 ^b	6.83
3.75	0.58 ^b	6.67

^{a-e}Concentrations with different superscripts within each temperature treatment were different ($P < 0.05$).

partment of Agriculture, Food Safety and Inspection Service (USDA-FSIS) Appendix A guidance for the control of *Salmonella* is commonly referenced for the control of pathogenic *E. coli* in cooked beef products since *Salmonella* is more heat resistant than pathogenic *E. coli*. The shortest time and lowest temperature combination included in Appendix A requires achieving 130° F and holding for 86 minutes. The objective of this experiment was to validate a 5 log₁₀ thermal reduction of generic *E. coli* in *sous vide* cooked beef steaks at various time and temperature combinations, including those outside USDA recommendations.

Procedure

The experiment was conducted in three independent replications. Beef *semitendi-*

nosus muscles, eye of round, were cut into 1" slices, vacuum packaged, and frozen until use. For each replication, steaks were thawed (48 hours at 39° F) and exposed to UV light for 15 minutes on each side to reduce natural microflora. Steaks were submerged in liquid inoculum (2 liters of *E. coli* ATCC 25922 overnight culture, approx. 8 log₁₀ colony forming units (cfu)/g) and internally inoculated with a pin pad inserted five times into each side of each steak to achieve a 7 log₁₀ cfu/g concentration. After inoculation, steaks were air-dried (30 min, 73° F), individually vacuumed sealed, and cooked in *sous vide* water baths. For cooked steaks, holding time started once the steak reached the target internal temperature. Duplicate steak samples were taken from raw, inoculated steaks and from steaks subjected to the following hold time/

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temperature combinations: 150 min/115° F, 420 min/ 115° F, 150 min/125° F, 193.5 min/125° F, 258 min/125° F, 322.5 min/125° F, 64.5 min/130° F, 86 min/130° F, 107.5 min/130° F; 2.25 min/145° F, 3 min/145° F, and 3.75 min/145° F. The median sampling times for 130° F and 145° F were taken directly from the Appendix A 5 log₁₀ reduction table, and the other times were +/- 25% of the intermediate time. The 258 min sampling time for 125° F was extrapolated from the table. The 115° F sampling times represented potential worst-case scenarios and sous vide manufacturer's cooking guidance. Core samples (25 g) were homogenized, serially diluted, and plated onto Charm EC Peel plates for rapid detection of *E. coli* concentrations. *E. coli* colonies were counted after incubation (24 hours at 95° F)

according to manufacturer guidelines and reported as log₁₀ cfu/g. Reductions were determined by subtracting concentrations at given sampling times from the raw sample. Data were analyzed using PROC GLM contrasts in SAS 9.4.

Results

The minimum holding time (time at target internal temperature) measured for a 5 log₁₀ cfu/g reduction for 125, 130, and 145° F was 258 , 64.5 , and 2.25 minutes, respectively ($P < 0.01$; Table 1). These data confirm the utility of Appendix A time, temperature tables for a 5 log₁₀ cfu/g reduction of generic *E. coli* at 130 and 145° F and suggest the possibility for safely sous vide cooking steaks at 125° F. Alternatively, 115°

F cooking was insufficient for reducing the target concentrations of *E. coli*, with a final reduction of only 1.07 log₁₀ cfu/g ($P < 0.01$) after 420 minutes. Although a pathogenic strain of *E. coli* was not used in this study, the insufficient reduction of generic *E. coli* at 115° F highlights the potential risk of sous vide cooking beef at low temperatures. Further experimentation is needed to determine the fate of pathogenic *E. coli* during sous vide cooking of steaks using time and temperature combinations at and below recommended by USDA-FSIS.

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